ASSESSMENT OF BRACKISH WATER QUALITY FROM LETKHOKKON AREA IN YANGON REGION, MYANMAR

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Abstract

Eutrophication is the most studied form of coastal marine pollution. Eutrophic waters are characterized by excessive algae growth as a consequence of nutrient enrichments of coastal surface waters. In this research, totally 9 brackish water samples were collected from Letkhokkon area, seasonally in 2017. The aim of this research work is to study the water quality criteria of brackish water samples around Letkhokkon area and to identify eutrophication level of the studied area. Physicochemical and microorganisms investigations have been carried out by conventional and modern instrumental techniques and compared with the acceptable levels of ASEAN and EPA standards for human health and aquatic life protection. Sampling sites were recorded with GPS detector. According to the research, the eutrophic level (high nutrient-enrichment) was found in the hot season and the mesotrophic level (medium nutrient-enrichment) was found in the cold and rainy seasons.

Keywords: ASEAN, brackish water, EPA, eutrophication, eutrophic waters, mesotrophic level

Introduction

Brackish water is a type of water which has less salt in its water than in sea water. Brackish water is comprised of both seawater and fresh water as well. And it can be found in areas where lakes and rivers meet the ocean. Brackish water cannot be used as drinking water because tons of organisms which carry diseases thrive best in this type of water environment. Brackish water has a lower salinity than regular sea water. The saltiness of the sea water helps to eliminate these organisms. Brackish water usually takes on a brownish murky color. Swamps are made up of brackish water. An example of a type of swamp is the Mangrove swamps. Theses swamps act as a buffer which helps to separate the sea water from the brackish water. Technically, brackish water contains between 0.5 and 30 g of salt per liter more often expressed as 0.5 to 30 parts per thousand (ppt or %). Table 1 shows the water salinity based on the dissolved salts.

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Table 1: Water Salinity Based on Dissolved Salts in Parts Per Thousand (ppt)

No	Water	Dissolved Salt (ppt)
1	Fresh water	<0.5
2	Brackish water	0.5-30
3	Saline water	30-50
4	Brine water	>50

Materials and Methods

Study Area

There are many beautiful beaches in Myanmar, such as Ngapali, Chaung Tha, Ngwe-saung, Maungmagan, Kanthaya, Setse' and Letkhokkon beaches. The studied area, Letkhokkon beach is situated less than 100 km to the south of Yangon. This is the nearest beach resort to Yangon, a distance of just under three hours drive after ferry-crossing the Yangon river. Although most of Myanmar's beaches feature crystal-clear water and powdery white sands, the Bago River flows into this area, turning it into a dark mud flat. The beach is certainly not tempting for swimming due to mud. It is however idyllic and little visited (Figure 1) (Wikipedia, 2014).

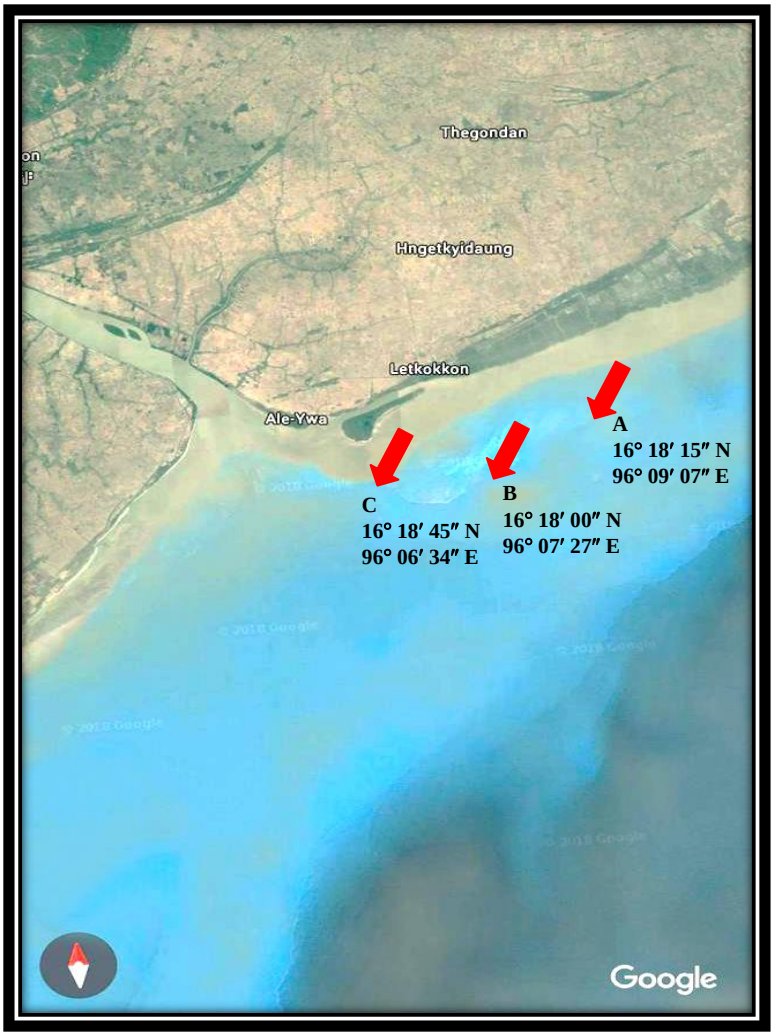

Figure 1: Satellite image of Letkhokkon beach
Sampling site – A (Near Seal Eain Tenn village)
Sampling site – B (Near Khanyein Kone Village)
Sampling site – C (Near Ahlae Village)

Table 2: Sampling Stations and Sampling Dates of Brackish Water Samples

Sample	Sampling Station		Sampling date
	Longitude (E)	Latitude (N)	
A	96° 09′ 07″	16° 18′ 15″	(30.3.17)
B	96° 07′ 27″	16° 18′ 00″	Hot Season
C	96° 06′ 34″	16° 18′ 45″	
A	96° 09′ 07″	16° 18′ 15″	(12.8.17)
B	96° 07′ 27″	16° 18′ 00″	Rainy Season
C	96° 06′ 34″	16° 18′ 45″	
A	96° 09′ 07″	16° 18′ 15″	(3.12.17)
B	96° 07′ 27″	16° 18′ 00″	Cold Season
C	96° 06′ 34″	16° 18′ 45″	

Sampling and Analytical Methods

In 2017, 9 brackish water samples were seasonally i.e, hot season (march), rainy season (August) and cold season (December) collected from 3 different sites A, B and C at Letkhokkon area, Yangon region (Table 2). Brackish water samples was taken 1 mile away from the bank and 1 meter depth from the surface water level. Polyethylene bottles were used for samples collection and storage. Physicochemical and microorganism detections were done by conventional methods and modern instrumental techniques.

Physicochemical parameters such as – temperature, pH, total alkalinity, total hardness, turbidity, total suspended solid, chlorinity, salinity, biochemical oxygen demand, chemical oxygen demand, dissolved oxygen, orthophosphate and total nitrogen contents in brackish water samples were analyzed along the Letkhokkon in order to monitore the quality of the brackish water. The pH of brackish water samples was determined by pH meter. The total alkalinity of brackish water samples were determined by titrating the sample with a standard solution of sulphuric acid using methyl orange as indicator. The total hardness of brackish water samples were determined by EDTA titrimetric method. Chlorinity and salinity of brackish water samples were determined by Mohr's modified method. The turbidity of brackish water samples was determined by turbidity meter. Total suspended

solid of brackish water samples were determined as the residue left after evaporation of the filtered water samples. Biochemical oxygen demand (BOD) of brackish water samples was measured by incubating the samples at 20 ^{o}C for 5 days. Chemical Oxygen demand (COD) of brackish water samples was measured by the permanganate oxidation method. The DO of brackish water samples was measured by DO meter. The content of orthophosphate was determined by UV-visible spectrophotometer. Total nitrogen contents in brackish water samples were determined by azo-dye method. Concentrations of some metal (Pb, Cd, Hg and As) in brackish water samples were determined by using Atomic Absorption Spectrophotometer (AAS) and microorganism indicators (total coliforms and *E. coli*) of brackish water samples were determined by multiple tube method.

Results and Discussion

The physicochemical properties of brackish water samples are shown in Tables 3, metal content in Table 7 and the microbiological properties in Table 8. The resultant data are illustrated in Figure 2 to 17. All of these results were observed in hot, rainy and cold seasons in 2017.

Temperature

The temperature of surface water is influenced by latitude, altitude, season, time of day, air circulation, cloud cover and the flow and depth of the water body. In this research, the temperature fluctuate seasonally in the range of between 28.34 ^{o}C and 30.54 ^{o}C. The minimum temperature 28.34 ^{o}C was found at sampling site A in rainy season due to the strong wind and rain (Table 3 and Figure 2).The maximum temperature 30.54 ^{o}C was found at sampling site C in hot season due to the intensity of solar radiation and evaporation. According to the resulting temperature range, the aquatic organisms which they can live normally in this study area.

pH

pH is an important parameter in water quality assessment as it influences many biological and chemical process within the water body. From the seasonal sample collection, the pH values of brackish water samples were

found in the range of between 7.70 and 8.00. The minimum pH value 7.70 was found at sampling sites B and C in rainy season. The maximum pH value 8.00 was found at sampling site C in hot season, because of the photosynthesis and respiration cycles of algae in eutrophic water (Strickland and Parsons, 1972) (Table 3 and Figure 3). In water body, point source pollution is a common cause that can increase or decrease pH depending on the chemicals involved. These chemicals can come from agricultural runoff, wastewater discharge or industrial runoff (Waterman, 2005). In the study areas, the observed pH values did not exceed the ASEAN standard (2010) (6.5-8.5) and EPA standard (2010) (6.0-8.0). However, these values were found to be slightly alkaline. pH can indirectly affect aquaculture species through its effect on other chemical parameters. So, the resulting pH value is good for aquatic life and fisheries.

Total Alkalinity

Total Alkalinity were attributed to the presence of hydroxide, carbonate and bicarbonate ion in the water sample. pH and alkalinity are directly related when water is at 100 % air saturation. Due to the presence of carbonates, alkalinity is more closely related to hardness than to pH (though there are still distinct differences). However, changes in pH can also affect alkalinity levels (as pH lower, the buffering capacity of water lowers as well). The total alkalinity of brackish water samples were observed in the range of between 100 ppm and 140 ppm. The lowest total alkalinity value 100 ppm was found at sampling sites C and B in rainy season and cold season. The highest total alkalinity values 140 ppm was found at sampling site C in hot season. It indicates that the concentration of basic compounds were higher in this sampling site C. These values are higher than the human health protection of ASEAN (2010) permissible guidelines (< 120 ppm) but within EPA standard (2010) of 30-150 ppm. Highly alkaline waters are usually unpalatable. Excess alkalinity in water is harmful for irrigation which leads to soil damage and reduce crop yields (Table 3 and Figure 4). Total alkalinity is not usually of concern for brackish water aquaculture. The desirable total alkalinity range is between 100 and 400 ppm is sufficient for aquaculture purpose.

Total Hardness

Total hardness of water is characterized with high mineral contents that are usually not harmful for humans. It is often measured as calcium carbonate ($CaCO_3$) because it consist mainly of calcium carbonate, the most dissolved ions in hard water (Chapman, 1996). In this research, the total hardness of brackish water samples were observed in the range of between 8890 and 9860 ppm. ASEAN and EPA standards (2010) values for total hardness in brackish water were not of concern (NC). The lowest total hardness value 8890 ppm was found at sampling site B in rainy season. The highest total hardness value 9860 ppm was found at sampling site A in hot season, due to the present of dissolved salts and the extensive geological formation of limestone in these area (Table 3 and Figure 5).

Chlorinity

Chloride is one of the major anions to be found in water and sewage. In this study, the chlorinity of brackish water samples was found in the range of 18.00 to 20.00 ppt. The lowest chlorinity value 18.00 ppt was found at sampling site C in rainy season due to the dilution effect of rain water. In hot season, concentration of the chlorinity value of 20.00 ppt was found in sampling site A. The chlorinity are of concern in water supplies used for aquaculture because the anion of chloride are essential for osmotic, ionic and water balance in all fish. These observed values were within the allowable limit of ASEAN standard (2010) for human health protection (Table 4 and Figure 6).

Salinity

Salinity measures dissolved inorganic content in water and usually expressed as parts per thousands (ppt). Salinity directly affects the level of dissolved oxygen, the higher the salinity, the lower the DO level at a given water temperature. The salinity of brackish water samples was found in the range of between 19.00 and 26.00 ppt. The lowest salinity value 19.00 ppt was found at sampling sites B and C in rainy season due to the dilution effect of rain water. The highest salinity value 26.00 ppt was found at sampling site A in hot season due to the high rate of evaporation, low rain fall and absence of river discharge. These values were agreed with the permissible level of

ASEAN standard (2010) (Table 4 and Figure 7). So, the water quality is good for the survival of brackish water fish.

Turbidity

Turbidity is a measure of cloudiness in water. In this study, the turbidity of brackish water samples was observed in the range of 5.90 to 8.30 FTU. These observed turbidity values was within the allowable limit of ASEAN standard (2010) and EPA standard (2010) for human health and aquatic life protection. The lowest turbidity value 5.90 FTU was found at site B in cold season. The highest turbidity value 8.30 FTU was found at sampling site A in hot and rainy seasons and it was noticed that the decrease in water clarity. In this sample, turbidity is related to the total suspended solid. Increase total suspended solid (TSS) has a similar effect to turbidity in that water. The highest turbidity can be caused the water clarity is reduced, water temperature can rise, oxygen level can fall as a result of less photosynthesis, and soil can bind to toxic compounds and heavy metal (Strickland and Parson,1972) (Table 4 and Figure 8).

Total Suspended Solid (TSS)

Total suspended solids (TSS) include a wide variety of material, such as silt decaying plant and animals matter, industrial wastes and sewage (APHA, 1992). The TSS of brackish water samples were found in the range of between 240 and 290 ppm. These values exceeded the ASEAN standard (2010) (< 75). The minimum turbidity value 240 ppm was found at sampling site B in cold season. The maximum TSS value 290 ppm was found in sampling site A in hot and rainy seasons, due to the high flow rate, soil erosion, urban and fertilizer run-off, waste water and septic effluents, decaying plants and geological features in these area. High level of TSS can cause gill irritations and tissue damage, with increase the stress levels of aquatic animals. In terms of water quality, high levels of total suspended solids will increase water temperatures and decrease dissolved oxygen (DO) levels (Table 4 and Figure 9).

Biochemical Oxygen Demand (BOD)

Biochemical oxygen demand (BOD) denotes the amount of oxygen needed by microorganisms for stabilization of decomposable organic matter under aerobic conditions. In this study, the BOD values of brackish water

samples was found in the range of between 1.00 and 2.00 ppm. The lowest BOD value 1.00 ppm was found at sampling site C in hot and rainy season. The highest BOD value 2.0 ppm was observed at sampling site A in hot and cold season. Unpolluted water typically has biochemical oxygen demand values of 2 ppm O_2 or less. These observed BOD values were within the ASEAN standard (2010) of < 15 ppm and EPA standard (2010) of 5 ppm for human health and aquatic life protection (Table 5 and Figure 10). So, the water quality is good for the brackish water fish.

Chemical Oxygen Demand (COD)

The chemical oxygen demand (COD) is a measure of the oxygen equivalent of the organic matter in a water sample. In this research, COD of brackish water samples was found in the range of 2.00 to 3.52 ppm. The lowest COD contents 2.00 ppm was found at sampling site C in rainy season probably due to the rainfall and run off. The highest COD contents 3.52 ppm was found at sampling site A in hot season. There is no major industries in the studies area, however, small scale industries like coconut husk retting are well established near the banks of the sea. It has negative impact such as the sharp rise and fall of pH, DO and also released toxic chemicals on the aquatic life and their sustainability. These values were within the allowable limits for human health and aquatic life protection of ASEAN standard (2010) and EPA Standard (2010) (Table 5 and Figure 11).

Seasonal Variation of Nutrient Level in Brackish Water Samples

Dissolved Oxygen (DO)

DO is an important indicator of water quality. The dissolved oxygen (DO) values of brackish water samples was found in the range of 2.00 to 3.50 ppm. The lowest DO value 2.00 ppm was found at sampling sites A and B in hot and cold seasons. Physical condition such as temperature, altitude and salinity can also affect oxygen level. The temperature and salinity increase, the solubility of oxygen in the water decreases. The highest DO value of 3.50 ppm was found at sampling site A in rainy season. In rainy season, heavy rainfall in the sea because of its churning dissolves more oxygen than still water, such as that in a reservoir behind a dam (Chapman, 1996). The resulting data are lower than the human health and aquatic life protection of ASEAN standard (2010) and EPA standard (2010) (Table 6 and Figure 12).

Orthophosphate

Phosphorus is usually present in natural water as phosphates (orthophosphates, polyphosphate, and organically bound phosphate). Soluble reactive phosphorus is a measure of orthophosphate (inorganic phosphate) that is dissolved or suspended in water. Excess phosphorus causes extensive algal growth called "blooms", which are the classic symptom of cultural eutrophication and lead to decrease oxygen levels in water body. In this research, the orthophosphate of brackish water samples was found in the range of 0.10 to 0.30 ppm. The lowest orthophosphate value 0.10 ppm was found at sampling sites B and C in hot season. The highest orthophosphate value 0.30 ppm was found at sampling sites A and C in rainy seasons and sampling site A in hot season. This may be due to the land runoff contaminated with super phosphate and from soap and detergents used by the public for bathing and washing clothes near water body. These values exceeded the ASEAN standard (2010) value 0.015 ppm (Table 6 and Figure 13).

Total Nitrogen

Nitrogen occurs in natural waters as nitrate, nitrite, ammonia and organically bound nitrogen. In this research, the total nitrogen of brackish water samples were observed in the range of 0.20 to1.00 ppm. The lowest total nitrogen value 0.20 ppm was found at sampling site B in hot season. The highest total nitrogen value 1.0 ppm was found at sampling site A in hot and rainy seasons. This may be due to the land runoff contaminated with fertilizer from the surrounding coconut gardens and vegetation (Table 6 and Figure 14).

In surface waters, phosphorus concentration exceeding 0.05 ppm may cause eutrophic conditions. If excessive amounts of phosphorus and nitrogen are added to the water, algae and aquatic plants can grow in large quantities. When these algae die, they are decomposed by bacteria. The decomposer use up the dissolved oxygen of the water body. The dissolved oxygen concentration often drop too low for fish to breathe, leading to fish kills (Waterman, 2005).

According to the evaluation degree of nutrient level, the studied areas around Letkhokkon Beach were identified as Mesotrophic level (medium nutrient enrichment) in rainy and cold seasons (Table 6). Eutrophic level (high nutrient enrichment) was found in hot season, due to the lesser amount

of fresh water inflow and high salinity. According to the results, it can be deduced that the studied areas are eutrophicated with nitrogen and phosphorus during the studied period within 2017.

Seasonal Variation of some Metals Contents in Brackish Water Samples

Most chemicals dissolved in brackish water are classified as some metals simply because so many ions and molecules are present at very low concentrations. Some metals in brackish water varied according to their locations and their depths. Some metals (Pb, Cd, Hg and As) contents of brackish water sample were determined by using Atomic Absorption Spectrophotometer (AAS). In this study, The Pb and Cd contents in brackish water sample were found in the range of 0.001 to 0.004 ppm and 0.005 to 0.009 ppm, respectively. The lowest Pb concentration of 0.001 ppm was found at sampling site C in rainy season and sampling sites A and C in cold season. The highest Pb concentration of 0.004 ppm was found at sampling site A in hot season. The minimum Cd concentration of 0.005 ppm was found at sampling site B in rainy season and the maximum Cd concentration of 0.009 ppm was found at sampling site A in hot season. The mercury and arsenic contents were not detected during the studied period of 2017. Industrial activity, anthropogenic activity and soil waste disposal may lead to increase some metal acidification of water bodies (Kyaw Naing, 2011). According to the results, some metal concentrations were within the allowable limits of ASEAN standard (2010) and EPA Standard (2010). Therefore, some metal pollution in Letkhokkon area is not at a level to affect the aquatic life and human health (Table 8 and Figures 15 and 16).

Seasonal Variation of Microorganisms Indicators (Total Coliform and *E.coli*) in the Brackish Water Samples

For the microbiological analysis of water samples in relation to human health, it is necessary to determine principally the pathogenic organism. Microbiological properties such as (Total coliforms and *E.coli*) of brackish water samples were determined by multiple tube method. In this research, total coliforms were found to be in the seasonal range of between 16 MPN/100 mL and 18 MPN/100 mL. The minimum total coliform value 16 MPN/100 mL was found at sampling sites A, B and C in cold season. The

maximum total coliform value 18 MPN/100 mL was found at sampling site A, B and C in hot season (Table 9 and Figure 17). These resultant values were within the allowable limits of the ASEAN standard (2010) for human health protection 100 MPN/100 mL. The number of Escherichia coli (*E.coli*) was not isolated in all brackish water samples during the studied period of 2017. ASEAN standard (2010) for *E.coli* value is Not of Concern (Table 9). According to the results, the studied regions were not polluted and adversely effect on aquatic life from the microorganism point of views.

Table 3: Seasonally Variation of Some Physicochemical Properties of Brackish Water Samples from Three Sampling Sites

Sampling sites	Season	Water Parameters			
		Temperature (^{o}C)	pH	Total alkalinity(ppm)	Total hardness(ppm)
A	Hot	29.64	7.90	110	9860
B		30.23	7.80	120	9840
C		30.54	8.00	140	9700
A	Rainy	28.34	7.80	120	9800
B		28.44	7.70	110	8890
C		28.42	7.70	100	9840
A	Cold	29.24	7.90	110	9800
B		29.46	7.80	100	9700
C		29.55	7.80	120	9600
ASEAN Standards (2010)		-	6.0-8.0	<120	NC
EPA Standards (2010)		-	6.5-8.5	30-150	NC

*NC – Not of Concern

Table 4: Seasonally Variation of Some Physicochemical Properties of brackish Water Samples from Three Sampling Sites

Sampling sites	Season	Water Parameters			
		Chlorinity (ppt)	Salinity (ppt)	Turbidity (FTU)	Total Suspended Solid (ppm)
A	Hot	20.00	26.00	8.30	290
B		18.65	24.00	7.50	250
C		18.40	25.00	7.60	260
A	Rainy	18.20	20.00	8.30	290
B		18.10	19.00	8.20	260
C		18.00	19.00	8.00	270
A	Cold	19.00	23.00	7.60	260
B		18.20	20.00	5.90	240
C		18.30	24.00	6.60	250
ASEAN Standards (2010)		>19	0.5-30	<700	<75
EPA Standards (2010)		-	-	15	NC

Table 5: Seasonally Variations of Some Physicochemical Properties of Brackish Water Samples from Three Sampling Sites

Sampling sites	Season	Water Parameters	
		BOD (ppm)	COD (ppm)
A	Hot	2.00	3.52
B		1.50	2.62
C		1.00	2.28
A	Rainy	1.50	2.20
B		1.10	2.10
C		1.00	2.00
A	Cold	2.00	3.00
B		1.50	2.40
C		1.40	2.20
ASEAN Standards (2010)		<15	<40
EPA Standards (2010)		5	-

Table 6: Seasonal Variation of Nutrient Level in Brackish Water Samples from Three Sampling Sites

Sampling sites	Season	Nutrient contents (ppm)			
		DO (ppm)	Orthophosphate (ppm)	Total Nitrogen (ppm)	Nutrient Enrichment
A	Hot	2.00	0.30	1.00	High
B		2.00	0.10	0.20	
C		2.50	0.10	0.30	
A	Rainy	3.50	0.30	1.00	Medium
B		2.50	0.20	0.80	
C		3.00	0.30	0.90	
A	Cold	2.50	0.20	0.30	Medium
B		2.00	0.15	0.30	
C		3.00	0.15	0.40	
ASEAN Standards (2010)		>5	0.015	-	
EPA Standards (2010)		-	-	-	

Table 7: Criteria for Evaluating Degree of Nutrient Over-Enrichment

Parameter	Low	Medium	High
N (ppm)	≤ 0.1	> 0.1 - < 1.0	≥ 1.0
PO_4^{3-} (ppm)	< 0.03	> 0.03 - < 0.3	≥ 0.3
DO (ppm)	≥ 5	> 2 – ≤ 5	0 - ≤ 2

(Tong and Deocadiz, 1999)

Table 8: Seasonal Variation of Some Metals Contents in Brackish Water Samples from Three Sampling Sites

Sampling sites	Season	Metal contents (ppm)			
		Pb	Cd	Hg	As
A	Hot	0.004	0.009	ND	ND
B		0.002	0.006	ND	ND
C		0.003	0.007	ND	ND
A	Rainy	0.002	0.007	ND	ND
B		ND	0.005	ND	ND
C		0.001	0.006	ND	ND
A	Cold	0.001	0.008	ND	ND
B		ND	0.006	ND	ND
C		0.001	0.007	ND	ND
ASEAN Standards (2010)		0.009	0.010	0.16	0.036
EPA Standards (2010)		-	-	-	-

*ND – Not Detected

Table 9: Seasonal Variation of Some Microorganism Indicators of Brackish Water Samples from Three Sampling Sites

Sampling sites	Season	Microorganisms	
		Total Coli form (MPN/100ml)	*Escherichia Coli* (MPN/100ml)
A	Hot	18	NI
B		18	NI
C		18	NI
A	Rainy	17	NI
B		17	NI
C		17	NI
A	Cold	16	NI
B		16	NI
C		16	NI
ASEAN Standards (2010)		100	NC
EPA Standards (2010)		-	NC

*NC – Not of Concern *NI- Not Isolated

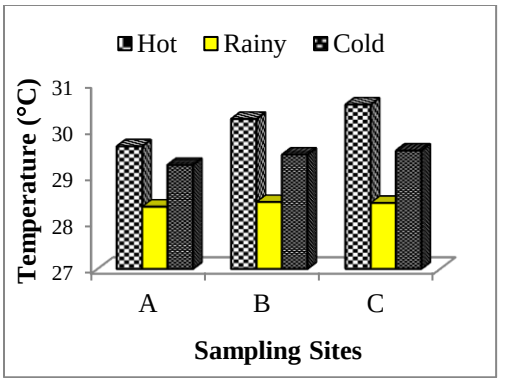

Figure 2: Bar graph of temperature in water samples from three sampling sites in three seasons

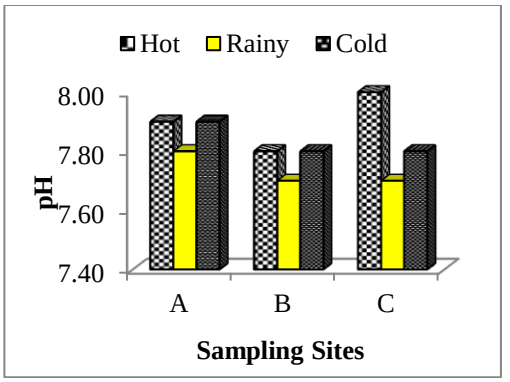

Figure 3: Bar graph of pH in water samples from three sampling sites in three seasons

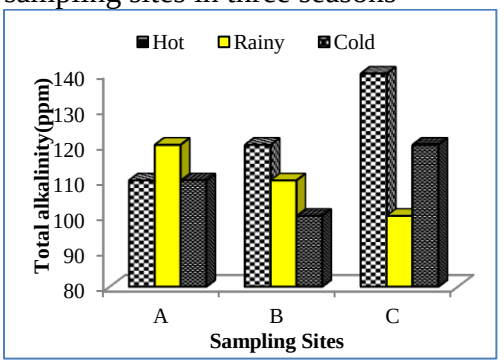

Figure 4: Bar graph of total alkalinity in water samples from three sampling sites in three seasons

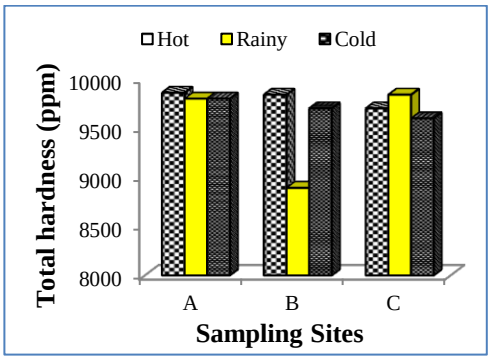

Figure 5: Bar graph of total hardness in water samples from three sampling sites in three seasons

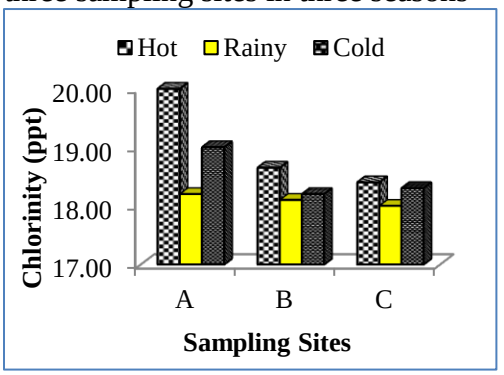

Figure 6: Bar graph of chlorinity in water samples from three sampling sites in three seasons

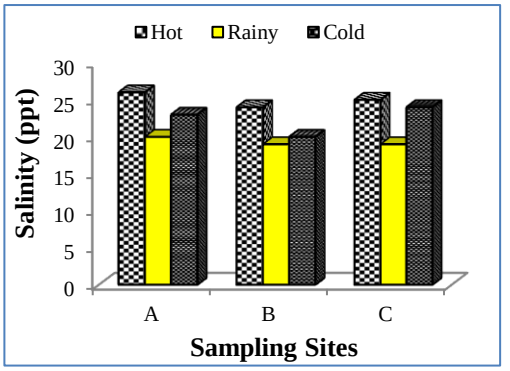

Figure 7: Bar graph of salinity in water samples from three sampling sites in three seasons

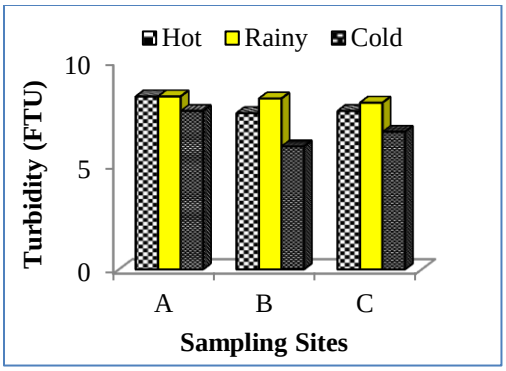

Figure 8: Bar graph of turbidity in water samples from three sampling sites in three seasons

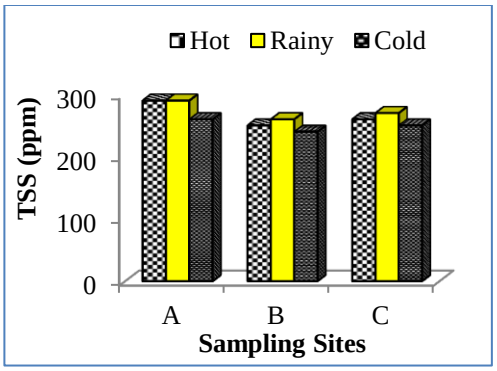

Figure 9:Bar graph of TSS in water samples from three sampling sites in three seasons

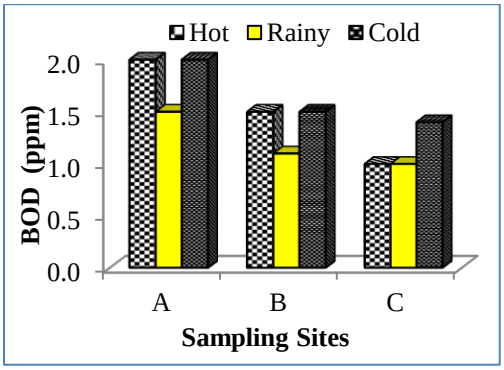

Figure 10: Bar graph of BOD in water samples from three sampling sites in three seasons

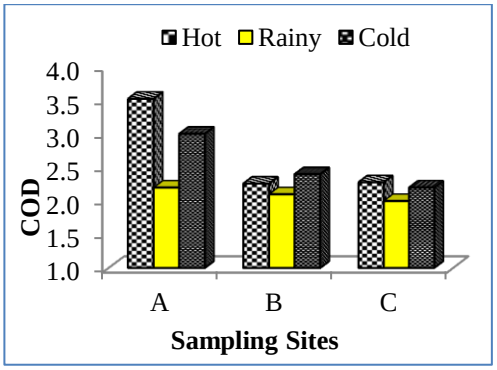

Figure 11: Bar graph of COD in water samples from three sampling sites in three seasons

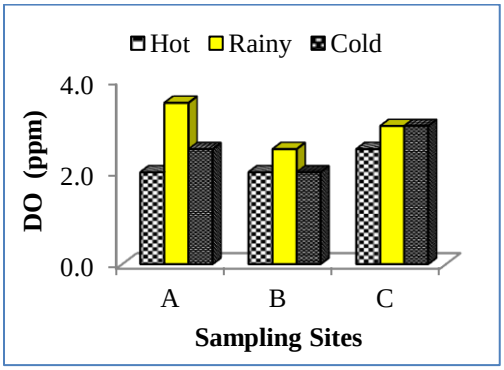

Figure 12: Bar graph of dissolved oxygen in water samples from three sampling sites in three season

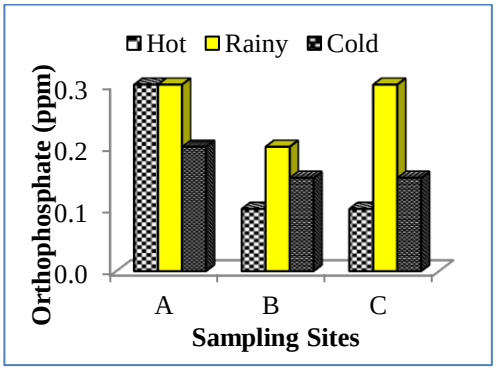

Figure 13: Bar graph of orthophosphate in water samples from three sampling sites in three season

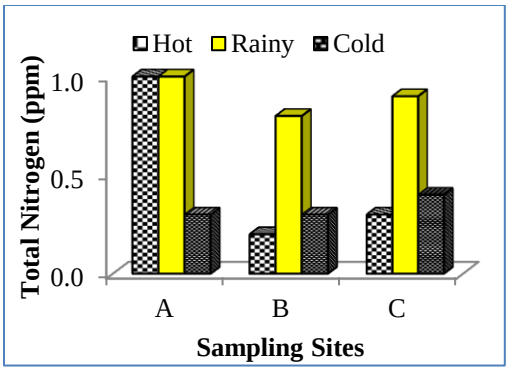

Figure 14: Bar graph of TN in water samples from three sampling sites in three seasons

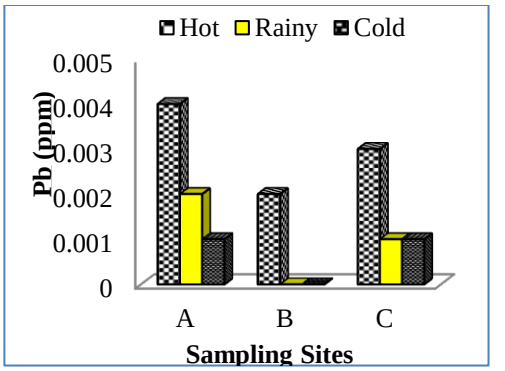

Figure 15: Bar graph of Pb in water samples from three sampling sites in three seasons

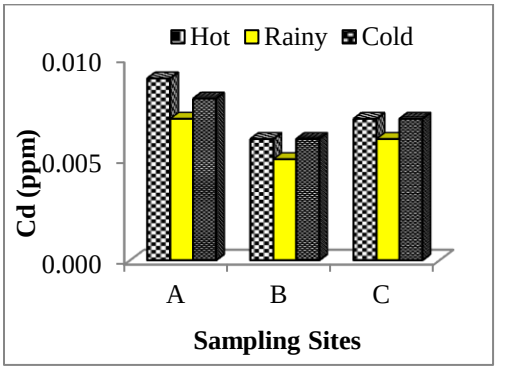

Figure 16: Bar graph of Cd in water samples from three sampling sites in three seasons

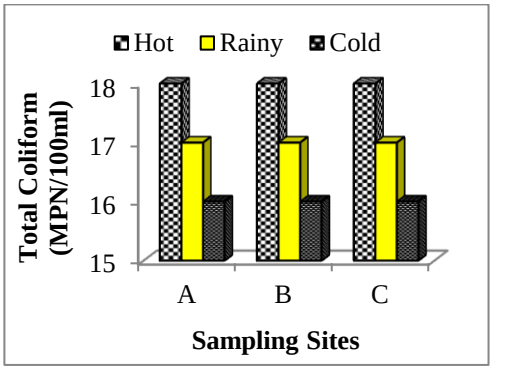

Figure 17: Bar graph of total coliform in water samples from three sampling sites in three seasons

Conclusion

Conclusively, the brackish water quality in terms of its physicochemical parameters, some metal concentrations and microorganism indicators in water from Letkhokkon area were assessed seasonally in 2017. The physicochemical properties of brackish water parameters-Temperature, pH, turbidity, DO, BOD, COD, chlorinity and total nitrogen concentrations were found within the range of ASEAN and EPA Standards for human health and aquatic life protection, however, total alkalinity, total suspended solid and orthophosphate contents were higher than the ASEAN and EPA standards (2010) for human health and aquatic life protection.

From the evaluation degree of nutrient level, the studied areas around Letkhokkon Beach were identified as Mesotrophic level (medium nutrient enrichment) in the rainy and cold seasons. Eutrophic level (high nutrient enrichment) was found in the hot season, it may be due to the lesser amount of fresh water inflow and high salinity. According to the results, it can be deduced that the studied areas were eutrophicated with nitrogen and phosphorus species during the studied period of 2017.

From the metal pollution point of views, some metal (Pb, Cd, Hg and As) concentrations of brackish water samples were within the allowable limits of ASEAN and EPA standards (2010) for human health and aquatic life protection. Therefore, metal pollution in Letkhokkon area were not at a level to affect the aquatic life and human health.

From the microorganism analysis of brackish water samples, the resultant data were within the allowable limits of ASEAN and EPA standards (2010) for human health and aquatic life protection.

According to the overall assessment of brackish water parameters, it can be concluded that the water quality of studied region might be used for aquaculture and agriculture purpose.

Acknowledgements

The authors would like to express their profound gratitude to the Department of Higher Education (Yangon Office), Ministry of Education, Yangon, Myanmar, for provision of opportunity to do this research and Myanmar Academy of Arts and Science for allowing to present this paper.

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